Technology Opportunity

System Stability of Aerospace Power Systems

NASA Lewis has been developing a specification flowdown methodology for stability design of spacecraft power systems. This methodology is also applicable to aircraft or other remote power systems. Noncommercial software to analyze the stability of power systems like that proposed for the international space station has been developed through a NASA Lewis research grant. The technology is focused on applications for aerospace and nonaerospace remote power systems.

Potential Commercial Uses

- Engineering analysis and design via component and system simulations, mostly in the frequency domain
- Specification flowdown in the design of power system components, to preclude adverse dynamic interactions that cause system instabilities and compromise performance
- Evaluation of the dynamic interactions pertaining to system stability, power quality, and control strategies for power systems
- Sensitivity analysis and its impact on system dynamic performance
- Automated frequency domain analysis tools tailored to the analysis of power systems
- Evolution of stability specifications to NASA, military, and commercial standards for wide applicability

Benefits

- Applicable to a wide range of nonutility, remote power systems, like those for spacecraft and aircraft
- Capable of deriving specifications and/or guidelines for designing stable power systems that also meet specified power quality limits and aid in electromagnetic interference (EMI) performance
- Capable of performing system stability analysis with small signal (frequency domain) analysis tools and techniques

The Technology

Recent advances in power system stability analysis, lead by university research, and also funded by NASA Lewis has resulted in analysis and/or design techniques, and noncommercial software tools that

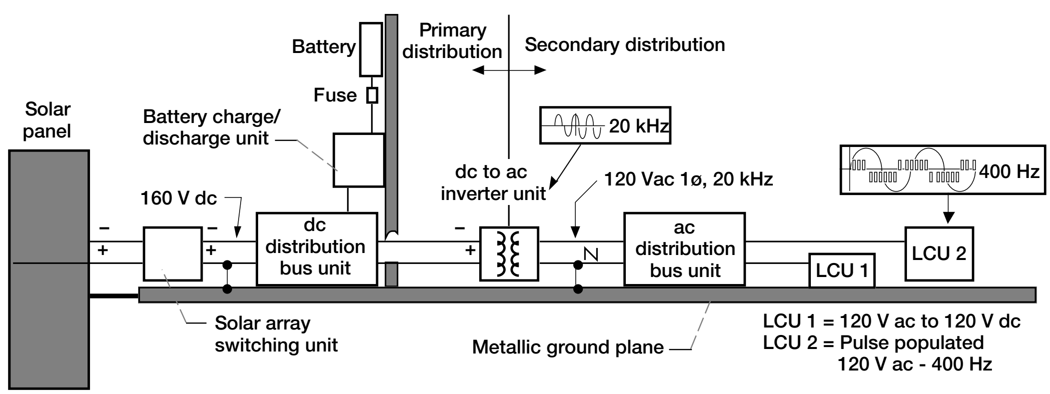

Figure 1.—Power distribution block diagram.

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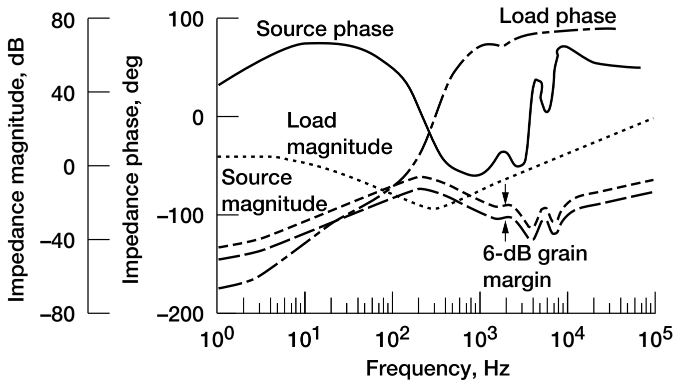

Figure 2.—System interface stability margins.

provide a methodical way of designing aerospace power systems for dynamic system performance. Figure 1 shows a spacecraft power system for which this design/analysis methodology would be applicable.

Power quality and EMI specifications do not fully characterize the dynamic behavior of the power system, because these areas do not address low-frequency dynamic couplings that can change the dynamics of the components in the system. With the incorporation of stability in the design, the system can operate stably with predictable and enhanced power quality and EMI performance.

Typical stability specifications are as follows:

1. Specify stability margins (phase and gain) at the system interfaces (typical 45°, 6 dB; see fig. 2)

2. Specify stability margins for the closed-loop gain for nonlinear sources and loads (typical 40°, 10 dB)

3. Specify Middlebrook stability criterion of 6 dB impedance separation at the output of the input EMI filter for nonlinear sources and loads

4. Specify sufficient damping for all load and source EMI filters and any bus filters, and in general, damping of all resonances (typical quality factor < 1)

5. Specify audio susceptibility for converter type sources and loads (typical, –30 dB)

6. Specify exclusion zone in the Nyquist or Bode (typically encompassing the radii of +/– 45° angles from the negative real axis in the Nyquist and the circle of 0.5 radius to the left that contains the point (–1 + j0); see fig. 3)

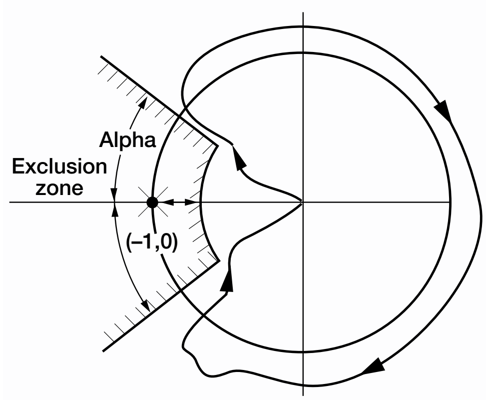

Figure 3.—Nyquist exclusion zone.

Options for Commercialization

Will provide technical assistance for commercial development of this technology.

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Key Words

Power system stability
Power system control
Frequency domain analysis

National Aeronautics and
Space Administration
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